Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	)	
	)	
Leica Geosystems AG,	)	No. _____
Request for Waiver of Part 15 of the	)	
Commission's Rules to Market a UAV	)	
Collision Avoidance Radar	)	

REQUEST FOR WAIVER

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REQUEST FOR WAIVER

Leica Geosystems AG requests a waiver of Section 15.255 of the Commission's rules to permit the marketing of a 60-64 GHz radar device that will be integrated in commercial Unmanned Aerial Vehicles (UAVs) used for visual capture of the outsides of structures. The radar will help to avoid collisions with stationary obstacles.

A. SUMMARY

Leica Geosystems' Ictos radar, installed on a UAV scanning the exterior of a structure, automatically prevents the UAV from colliding with the structure or other objects. In addition to averting property loss, the radar will reduce the risk of casualties on the ground from falling debris.

The ability to safely operate a UAV close to a structure opens a number of engineering and scientific applications that are not otherwise practicable.

The Ictos frequency range of 60-64 GHz allows the detection and avoidance of thin objects, such as cables, down to 2.5 mm in width. This choice of frequencies, together with specified power and out-of-band emissions, will avoid interference to other spectrum users, including the Earth Exploration-Satellite Service (EESS).

The Ictos system does not come within the Commission's definition of a field disturbance sensor, and so should not be subject to the provisions in Section 15.255 that relate to field

disturbance sensors. In the alternative, if the Commission decide these provisions apply, then Leica Geosystems requests their waiver as well.

We propose waiver conditions calculated to further contain any interference risk. These include FAA-mandated altitude limits, operation only while in motion, and restrictions on the numbers of devices sold.

B. ABOUT LEICA GEOSYSTEMS

Leica Geosystems is a part of Hexagon, which is a global engineering and manufacturing firm with a major focus on geospatial technologies. The company has more than 20,000 employees in 46 countries, with €3.8 billion (approximately US$4.25 billion) in annual sales. Fifty-five percent of its net sales are in service and software. The company invests 10-12% of sales in R&D, with 3,800+ employees in R&D, and 3,700+ active patents.

C. ABOUT THE ICTOS SYSTEM

UAVs can provide close-up views of structural exteriors that would otherwise be difficult or impossible to obtain. This capability can promote safety, support engineering studies, and aid scientific investigation. At present, however, safety considerations require planning the UAV flight path in aerial free space above all possible collision hazards. This typically limits inspections to top-down views, which in turn confines applications to simple environments such as open-pit mines, earth work, and open landscapes.

The Ictos system will facilitate UAV visual surveying in more complex settings, including:

- safety inspection of bridges;
- assessing structural integrity of buildings in danger of collapse (for example, after natural disasters);
- measuring the structural details of buildings to plan expansions;

- documenting construction progress, including ongoing checks against architectural and engineering plans;
- close-up visual surveying of roofs to optimize planning for solar panel installation; and
- visual surveying of archeological sites for computer aided analysis and documentation.

Even with a skilled pilot at the controls, UAV operation close to a structure risks the aircraft striking the object under study. The Ictos system's obstacle detection and avoidance radars address this problem. In addition to improving safety, the system increases efficiency and reduces flying time by scanning surfaces under the control of an automated flight path.

1. System requirements

Resolution and frequency: The system must be able to detect and avoid narrow obstacles (such as ropes and cables) down to 2.5 mm diameter. This requires a radar wavelength of double that size or smaller, which translates to a frequency of 60 GHz or greater.

Precision: The system must detect an obstacle with a resolution in measured distance of 50 mm. This requires an operating bandwidth of 3 GHz.

Range: 10 meters, to be able to brake a UAV flying at 5 meters/sec (11 mph) to a hovering state before colliding with the obstacle.

Field of view: Because UAVs fly sideways and backwards as well as frontwards, multiple radar modules can be combined to provide up to full spherical obstacle detection coverage. This sets an upper limit on the weight of each module.

2. Why 60 GHz?

Leica Geosystems considered several alternatives to 60 GHz radar, and rejected each for the reasons shown:

24 GHz radar: Not reliable against thin objects like cables.

76-81 GHz radar: Interference to and from automotive radars.

Ultrasonic range sensor: Susceptible to interference from UAV rotor noise; cannot localize obstacles.

LIDAR: Too heavy for required obstacle detection coverage.

Stereo cameras: Computational requirements too high.

Infrared time of flight: Fails in direct sunlight; not reliable against thin or dark-colored objects.

In addition to reliably detecting thin obstacles regardless of ambient lighting and sound, radar at 60 GHz can be constructed in a small form factor that is easy to integrate in an UAV.

3. Specifications for waivered device

The radar marketed under the requested waiver will conform to these specifications:

Frequency: The device will contain its intentional emissions within the 60-64 GHz band. (In fact the device occupies 60.5-63.5 GHz, but we specify 60-64 GHz to allow for any over-/undershoot from the FMCW modulation.)

Power at 60-64 GHz: Average power will not exceed 0 dBm EIRP and peak power will not exceed 18.7 dBm EIRP. (These values are 40 dB and 24 dB below the FCC's limits for average and peak power, respectively.[1])

[1] 47 C.F.R. § 15.255(c)(1)(i) (power limits of 40 dBm average, 43 dBm peak). There are lower limits for field disturbance sensors, which we argue below do not apply here.

Out-of-band emissions: Will not exceed -51.3 dBm EIRP. This is 41.4 dB below the FCC's out-of-band limit in the 40-200 GHz range, and 10 dB below the limit at frequencies below 40 GHz.[2]

Duty cycle: at or below 50%, integrated over 40 ms. (This is not accounted for in the power and out-of-band emissions values above, which for that reason could each be reduced by 3 dB.)

D. ISSUES RELATING TO FIELD DISTURBANCE SENSORS

Section 15.255 includes provisions that apply specifically to field disturbance sensors. We show here that the Ictos system is not a field disturbance sensor, under the Commission's definitions, notwithstanding an isolated Commission footnote that says otherwise. In the alternative, if the Commission determines that Ictos is a field disturbance sensor, then we request waiver of the additional relevant provisions.

1. Ictos is not a field disturbance sensor.

Ictos conforms to the Commission's definition of "radar," but not to its definition of "field disturbance sensor."

The Commission defines "radar":

> *Radar*. A radiodetermination system based on the comparison of reference signals with radio signals reflected, or retransmitted, from the position to be determined.[3]

The Commission defines the internal term "radiodetermination":

> *Radiodetermination*. The determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating

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[2] 47 C.F.R. § 15.255(d)(3) (out-of-band limit at 40-200 GHz is 90 pW/cm^2 at 3 meters, mathematically equivalent to -9.9 dBm EIRP; out-of-band limit below 40 GHz per Sec. 15.209 is 500 μV/m at 3 m, equivalent to -41.3 dBm).

[3] 47 C.F.R. § 2.1.

> to these parameters, by means of the propagation properties of radio waves.[4]

Combining the relevant elements of both:

> *Radar*: A system that determines the position and/or velocity of an object by means of the propagation properties of radio waves, based on the comparison of [transmitted] signals as a reference with those reflected from the position to be determined.

That is how Ictos operates: it emits a radio wave, detects the reflection, and compares the reflection to the transmitted signal to determine the location and relative velocity of the reflecting object.

A field disturbance sensor is something different:

> *Field disturbance sensor*. A device that establishes a radio frequency field in its vicinity and detects changes in that field resulting from the movement of persons or objects within its range.[5]

Intrusion alarms are an example. The device creates and maintains a field around an object or area to be protected. The movement of a person or object within the field causes a distortion in the field. The device detects that distortion to trigger an alarm.

The Ictos system does not fit this definition. It does not generate and maintain a field, but transmits an outward-traveling signal. It does not respond to a disturbance in a field, but to a reflection of the transmitted signal. Where a field disturbance sensor by definition detects only movement, the Ictos system detects both moving and stationary objects with equal ease.

The Commission has linked radars generally and field disturbance sensors only once, and then only in passing. One of 1,243 footnotes in a 177-page, single-spaced order reads in its

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[4] 47 C.F.R. § 2.1.

[5] 47 C.F.R. § 15.3(l).

entirety: "A radar is one type of field disturbance sensor."[6] There is no discussion or analysis. The accompanying text uses the word "radar" to describe applications of field disturbance sensors,[7] not radar as the Commission defines it (and not as Ictos uses it). Nothing else in this order—or any other we have found—suggests the Ictos technology belongs in the category of field disturbance sensors.

Entitled to at least equal weight is a Commission rule that refers to "field disturbance sensors and radar systems" as if they are different things (in three places).[8] Similarly, Section 15.255 refers to "[f]ield disturbance sensors, ***including*** vehicle radar systems"[9]—a qualification that would be unnecessary if all radars were a type of field disturbance sensor. And again, the Commission goes out of its way to define a ground penetrating radar as a type of field disturbance sensor,[10] and to identify certain sub-categories of radar as examples of field disturbance sensors[11]—likewise unnecessary if this were true for all radars.

We do not dispute the possibility of some overlap between the categories of radar and field disturbance sensors. But Ictos is not part of any such overlap. It is squarely radar, and squarely outside the definition of a field disturbance sensor.

Of course the Commission is the first authority on the construction of its own regulations,[12] but there are limits on its discretion. Deference to an agency's interpretation

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6 *Spectrum Bands above 24 GHz for Mobile Radio Services*, 31 FCC Rcd 8014 at ¶ 335, n.915 (2016) (*2016 Order*).

7 *2016 Order* at ¶¶ 334-37. The applications mentioned include industrial field disturbance sensors, detection of hand gestures, and in-room activity tracking.

8 47 C.F.R. §§ 95.3379(a)(2)(i), (a)(2)(ii), (a)(3).

9 47 C.F.R. § 15.255(a)(2) (emphasis added).

10 47 C.F.R. § 15.503(f).

11 *2016 Order* at ¶ 126 n.311.

12 *Auer v. Robbins*, 519 U.S. 452, 457-58 (1997).

> is warranted only when the language of the regulation is ambiguous. The regulation in this case, however, is not ambiguous … . To defer to the agency's position would be to permit the agency, under the guise of interpreting a regulation, to create de facto a new regulation.[13]

As in *Christensen*, the Commission's definitional distinction between "radar" and "field disturbance sensor" is unambiguous, and therefore is not subject to agency reinterpretation.

The Commission's reading likewise loses deference where it "does not reflect the agency's fair and considered judgment on the matter in question."[14] The conclusory footnote cited above, without more, hardly constitutes fair and considered judgment. Nor does a single, deeply buried footnote constitute adequate notice to the public that the definitions say something other than their plain English-language meanings. In the absence of a clear and reasonably prominent explanation to the contrary, the unambiguous language of the rule text must govern.[15]

We ask for a determination that the Ictos system is not a field disturbance sensor for the specific purpose of the present waiver request.

Section 15.255 sets no special limits on operation other than for field disturbance sensors, and for use on satellites and aircraft. If the Ictos radar system is not a field disturbance sensor, then it is eligible for authorization at the full power allowed under the rule. (As noted above, however, the system operates at far below that maximum power.)

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13 *Christensen v. Harris County*, 529 U.S. 576, 588 (2000).

14 *Christopher v. SmithKline Beecham Corp.*, 567 U.S. 142, 155 (2012), *citing Auer*, above, 519 U.S. at 462.

15 Moreover, any such explanation is binding on the public only if published in the Federal Register, FCC Record, FCC Reports, or Pike and Fischer. 47 C.F.R. § 0.455(f). A notice in the Laboratory Division's Knowledge Database (KDB), for example, would not in itself be adequate.

2. In the alternative, Leica Geosystems requests waiver of additional provisions.

If the Commission determines the Ictos device to be a field disturbance sensor, notwithstanding the above, then Leica Geosystems requests the waiver of certain provisions in Section 15.255 that relate to field disturbance sensors. We detail those in part E.2, below.

E. REQUEST FOR WAIVER

1. Aircraft provisions

Section 15.255(b)(2)(ii) provides:

> Equipment shall not be used on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft. These aircraft include, but are not limited to, toy/model aircraft, unmanned aircraft, crop-spraying aircraft, aerostats, etc.

Leica Geosystems requests a waiver of this provision to allow operation of the Ictos system on commercial UAVs, under the conditions described here.

The Commission's initial rules authorizing unlicensed use of 57-64 GHz, adopted in 1995, barred use on aircraft to prevent interference to radio astronomy operations.[16] The subsequent 2016 expansion of the band, to 57-71 GHz, likewise maintained the aircraft ban to protect radio astronomy, and also mentioned remote sensing passive services, including EESS.[17] Last year, the Commission reversed its earlier decisions: it allowed the use of 57-64 GHz on board closed aircraft, over objections from the National Academy of Sciences' Committee on

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16 *Use of Radio Frequencies above 40 GHz for New Radio Applications*, First Report and Order and Second Notice of Proposed Rule Making, 11 FCC Rcd 4481 at ¶ 35 (1995).

17 *2016 Order* at ¶¶ 329, 331-33 (2016).

Radio Frequencies (CORF), which represents radio astronomy and EESS interests.[18] The Commission excluded usage on certain types of aircraft that provide little RF attenuation, and in that context prohibited use on UAVs.[19]

Also last year, the Commission granted a waiver for operation of a 57-64 GHz field disturbance sensor system onboard aircraft at power levels higher than are provided for in the rules.[20] Again despite CORF's concerns about EESS interference, the Commission allowed the devices to operate at peak conducted output levels 20 dB higher than in the rules, and a peak power spectral density 3 dB higher than the rules.[21]

The Ictos system is carefully designed to avoid interference to EESS. Its 60-64 GHz frequency usage falls well outside all EESS bands. See Figure 1. Out-of-band emissions are far below the maximum in the rules, low enough not to affect EESS operations. The FAA height limit for UAVs, noted below, will further limit exposure. We are confident that the design will fully protect EESS.

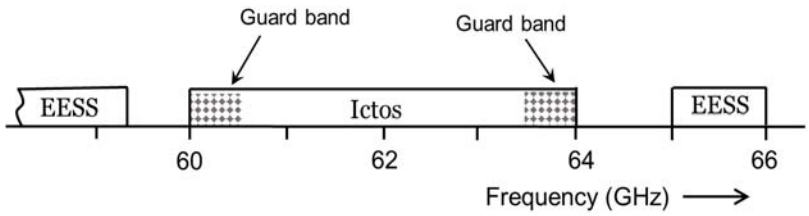

Figure 1 – Ictos and EESS frequency usage

[18] *Spectrum Bands above 24 GHz for Mobile Radio Services*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, 32 FCC Rcd 10988 at ¶¶ 75-87 (2018).

[19] *Id*. at ¶ 83.

[20] *Google LLC, Request for Waiver of Section 15.255(c)(3)*, 32 FCC Rcd 12542 (OET 2018). The device responds to users' hand gestures in three-dimensional space.

[21] *Id*. at ¶ 5.

2. Field disturbance sensor provisions

We explained in Part D.1 above that the Ictos system is not a field disturbance sensor under the Commission's definitions. If the Commission determines otherwise, then Leica Geosystems additionally requests waiver of these provisions:

> Sec. 15.255(a)(2): barring mobile field disturbance sensors unless used as short-range devices for interactive motion sensing; and
>
> Sec. 15.255(c)(3): limiting power in permitted field disturbance sensors to -10 dB peak conducted, and +10 dBm peak EIRP.[22]

The stated purpose of these restrictions is to avoid causing harmful interference to co-channel communications devices.[23] But nowhere in the 29-year history of these rules has the Commission explained why a field disturbance sensor is a greater interference threat to 57-71 GHz communications users than another, co-channel communications device.

In particular, there is no reason to expect the Ictos system to be more interfering than a communications device at similar (very low) power levels. Although the Ictos emissions exceed the allowable power for field disturbance sensors by a small amount (see Table 1), they remain tens of dB below the limits for other devices. The proposed sales limits on Ictos systems further reduce the likelihood of interference. Because the system operates only in motion, while 57-71 GHz communications systems tend to use narrow antenna beams, any interference that did occur would be transitory.

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[22] Separate rules for fixed field disturbance sensors within 61.0-61.5 GHz do not apply to the Ictos system.

[23] *2016 Order* at ¶ 334 (2016).

	average EIRP (dBm)	peak EIRP (dBm)
field disturbance sensor limit	*	10
Ictos	**0**	**19**
other 57-71 GHz limit	40	43
* not specified		

Table 1: Ictos and § 15.255 power limits

Because Ictos offers significant public interest benefits, and should not present an interference threat any greater than a compliant Section 15.255 device, waiver of Sections 15.255(a)(2) and 15.255(c)(3) is appropriate.

F. PROPOSED WAIVER CONDITIONS

To ensure lack of harm to EESS and other spectrum users, we propose the following waiver conditions:

- intentional emissions contained within 60-64 GHz;
- average and peak power not to exceed 9 dBm EIRP and 18.7 dBm EIRP, respectively;
- out-of-band emissions not to exceed -51.3 dBm;
- duty cycle not to exceed 50%, integrated over 40 ms;
- altitude limits not to exceed FAA maxima: 400 feet (122 meters) above ground unless within 400 feet of a structure, and then 400 feet above the structure;[24]
- radar operates only while the UAV is in motion and automatically turns off while the UAV is hovering; and
- U.S. sales not to exceed installation on 800 UAVs per year over five years. (Commercial UAVs that would benefit from the Ictos system have US-dollar prices in six digits; the device does not target the mass consumer market.)

[24] 14 C.F.R. § 107.51(b).

G. PUBLIC INTEREST

A collision between a UAV, weighing up to 55 pounds,[25] and a structure it is scanning risks damage to the UAV and to the structure, and injury to persons on the ground. Collisions can also cause damage to a structure, likely on an elevated part of the structure where repairs are difficult. Moreover, an object that weighs tens of pounds and falls from tens of meters can cause injury to personnel working near the structure and possibly to passers-by.

Preventing such collisions and their associated harms is in the public interest.

H. WAIVER STANDARD

"Good cause … may be found and a waiver granted 'where particular facts would make strict compliance inconsistent with the public interest.'"[26] That is the case here.

The Commission assesses waiver requests according to the standards set out in *WAIT Radio v. FCC*.[27] In that case, as here, the applicant sought to operate in contravention of the rules while explaining how it would nonetheless accomplish the purpose of the rules.[28] The court required the Commission to consider the request:

> [A] general rule, deemed valid because its overall objectives are in the public interest, may not be in the "public interest" if extended to an applicant who proposes a new service that will not undermine the policy, served by the rule, that has been adjudged in the public interest.[29]

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25 *See* 14 C.F.R. § 1.1 (definition of "small unmanned aircraft").

26 *SafeView, Inc.*, 25 FCC Rcd 592 at ¶ 15 (2010), *citing Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

27 418 F.2d 1153 (D.C. Cir. 1969). See also, *2002 Biennial Regulatory Review*, 18 FCC Rcd 13620 at ¶ 85 n.130 (2003) (citing *WAIT Radio* as "setting out criteria for waivers of Commission rules.")

28 WAIT Radio operated an AM broadcast station. It was limited to daylight hours so as to afford protection to "white areas" that had no local service, and that relied on nighttime skywave propagation from another station. WAIT Radio proposed to transmit at night using a directional antenna that would limit its signal in the white areas. *WAIT Radio v. FCC*, 418 F.2d at 1154-55.

29 *WAIT Radio v. FCC*, 418 F.2d at 1157.

The meaning is clear: Waiver is appropriate where the applicant furthers the public interest inherent in the underlying rule.

The waiver requested here meets the *WAIT Radio* standard: it proposes a "new service" that will not undermine the policy served by the rule. That policy serves to protect other services, particularly EESS, from interference. The Ictos system accomplishes that through design limitations on frequency, power, and out-of-band emissions. The requested waiver fits easily into the boundaries drawn by *WAIT Radio*.

The Court of Appeals emphasized the importance of waiver procedures as part of the regulatory scheme:

> The agency's discretion to proceed in difficult areas through general rules is intimately linked to the existence of a safety valve procedure for consideration of an application for exemption based on special circumstances.[30]

Thus, it said, "allegations such as those made by petitioners, stated with clarity and accompanied by supporting data . . . must be given a 'hard look.'"[31]

Here, too, the request fully qualifies. The "safety valve" of the waiver procedure is needed to make available an important tool that will protect expensive property and promote safety. The requested waiver is in the public interest, not only in terms of benefits to the public, but also in the absence of any likely increase in harmful interference. The request is entitled not only to the "hard look" mandated in *WAIT Radio,* but to a grant of the waiver.

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30 *Id.*

31 *Id.* (citation footnote omitted).

CONCLUSION

For the reasons set out above, Leica Geosystems asks the Commission to consider and grant the requested waiver.

Respectfully submitted,

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TECHNICAL CERTIFICATION

I am a technically qualified individual who contributed to and/or reviewed the foregoing Request for Waiver. I certify that the technical statements therein are correct to the best of my knowledge.

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